

An Exploration of a UT/LS Ozone Transport Event Using HIRDLS Data

John Gille¹, Valery Yudin², Bruno Nardi², John Barnett³, Steven Massie², Tanya Phillips¹, Thomas Eden², Chris Halvorson², Craig Hartsough², Rashid Khosravi², Hyunah Lee[†], Cora Randall¹, Doug Kinnison²

¹University of Colorado, Boulder; ²National Center for Atmospheric Research; ³Oxford University; [†]Deceased

Goals of This Study

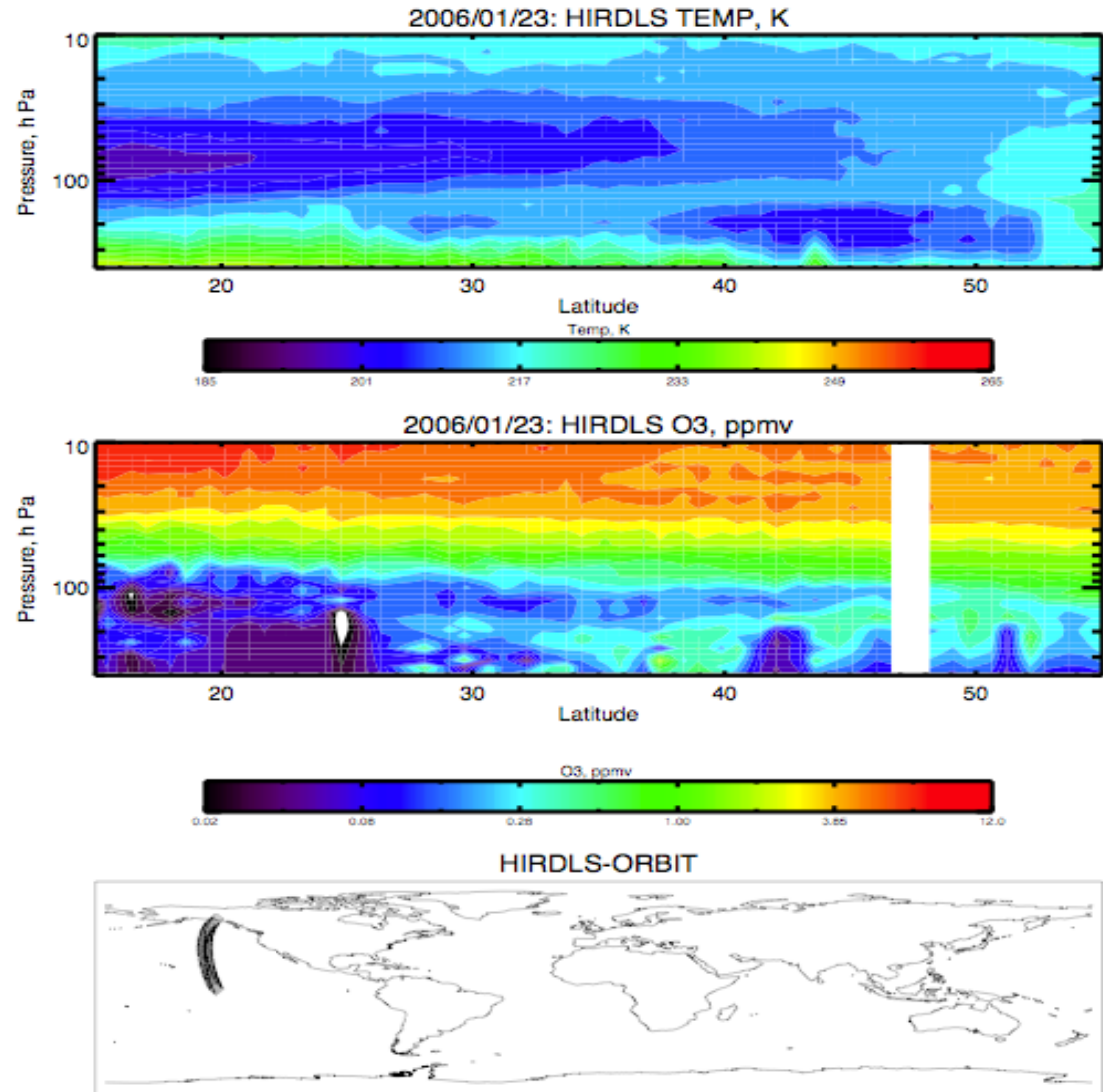
- **Examine ozone structure in the upper tropopause/lower stratosphere (UT/LS), looking for indications of UT air from low latitudes being transported into mid-lat LS, indications of mid-lat LS ozone transport into the tropical UT and effects of a sudden warming on LS ozone in mid-latitudes**
- **Explore ability of HIRDLS to observe the UT/LS air mass exchanges during solstice and equinox seasons (inspect 2006, Jan, Mar, Sep).**
- **Compare HIRDLS UT/LS air mass intrusions with other instruments and meteorological analyses.**

The HIRDLS Instrument

- **A 21 channel limb-scanning infrared radiometer with spectral range from 6 to 18 μm**
- **HIRDLS was designed to observe the region around the UT/LS**
 - Temperature and ozone channels with small absorption by CO₂ and O₃, allowing signals to emerge from the UT/LS region**
- **Detectors subtend about 1.2 km vertically at the limb, sampled every 200 m, permitting high vertical resolution**
 - Low noise levels, allow precise measurements**

Double Tropopause Structures and Strat-Trop Air intrusions observed by HIRDLS, Jan 23/2006

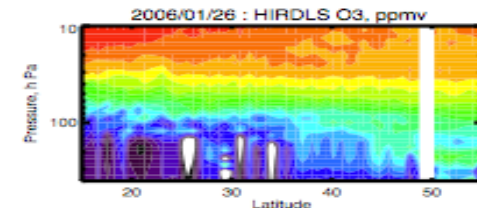
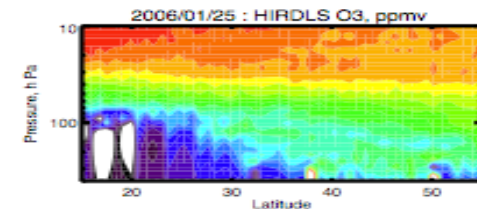
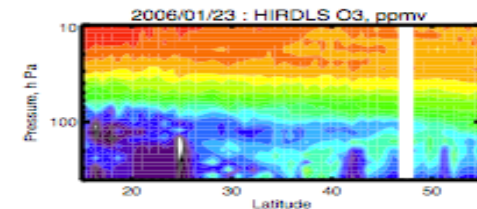
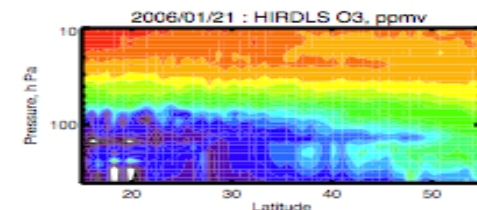
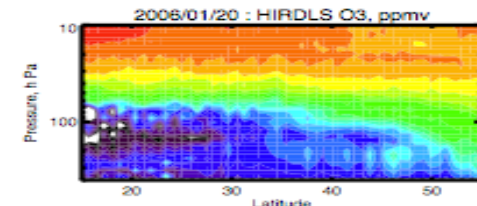
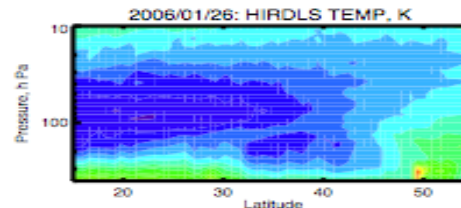
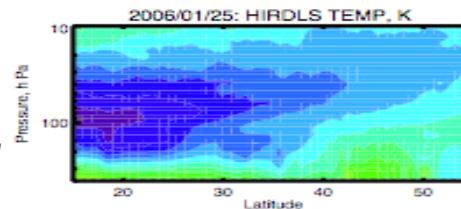
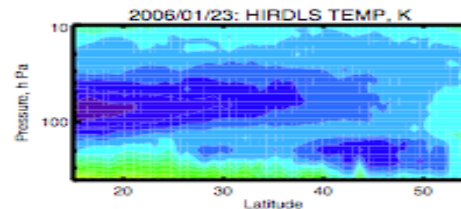
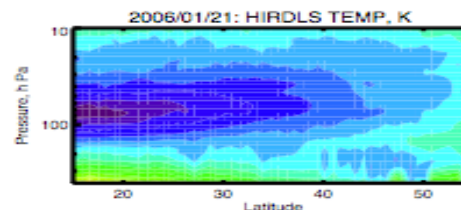
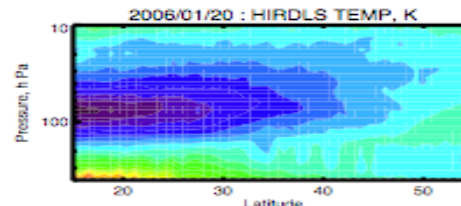
- Top panel-along-track vertical cross-section of HIRDLS-T for January 23, 2006, along an ascending part of the orbit shown in the bottom panel.
- Center panel-along-track vertical cross-section of HIRDLS ozone for the same orbit.
- Bottom panel shows ascending HIRDLS orbit



HIRDLS T and O3 cross-sections in the UT/LS region: Jan 20-26 2006, one week after major Arctic warming event in the UT/LS

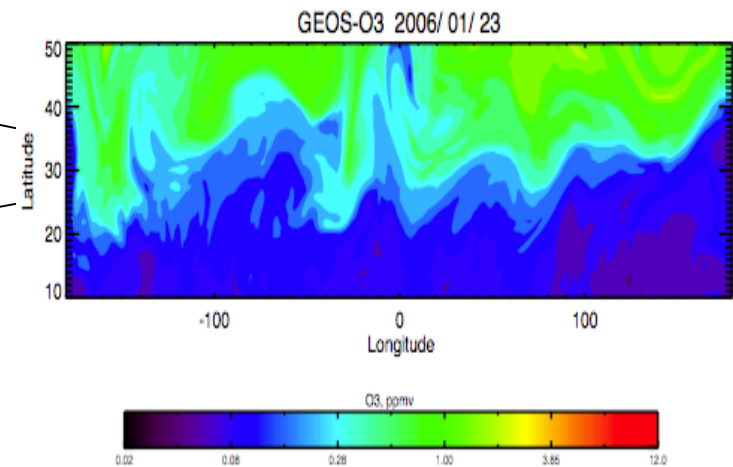
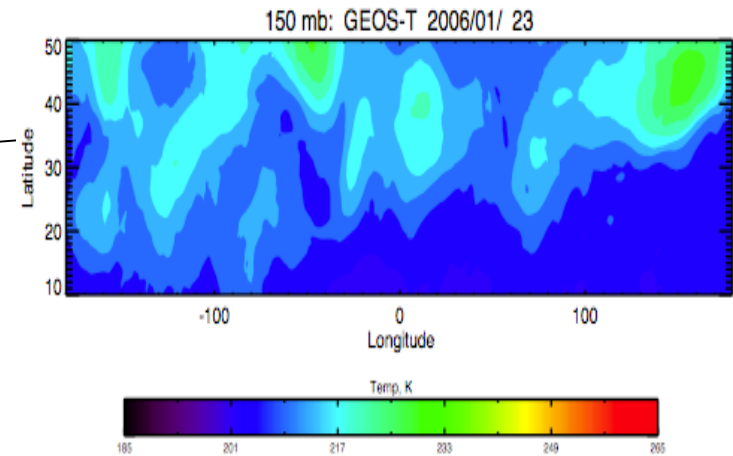
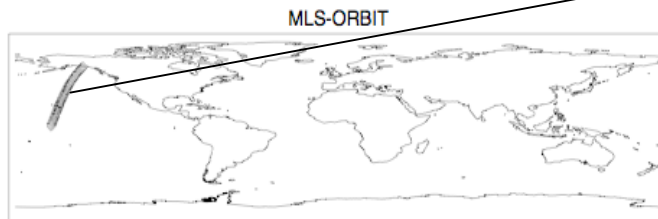
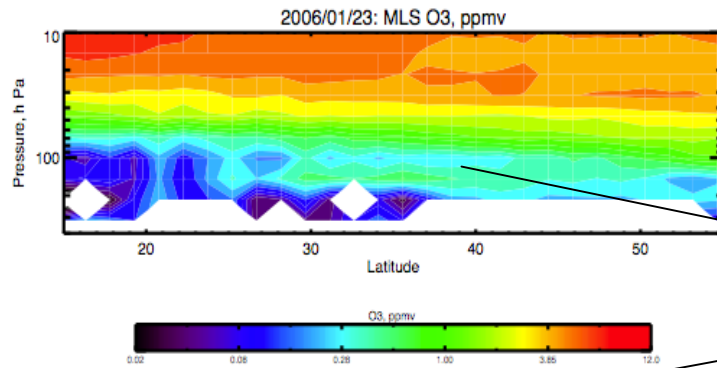
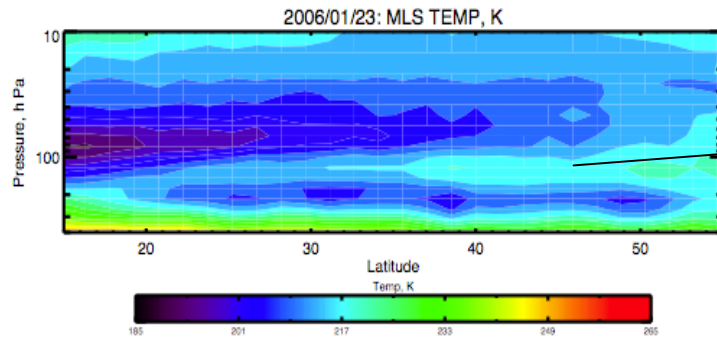
Along-track temperature and ozone fields for late January, 2006, showing evolution of transports between low-latitude UT and mid-latitude LS

Days from the top:
January 20, 21, 23, 25, 26.



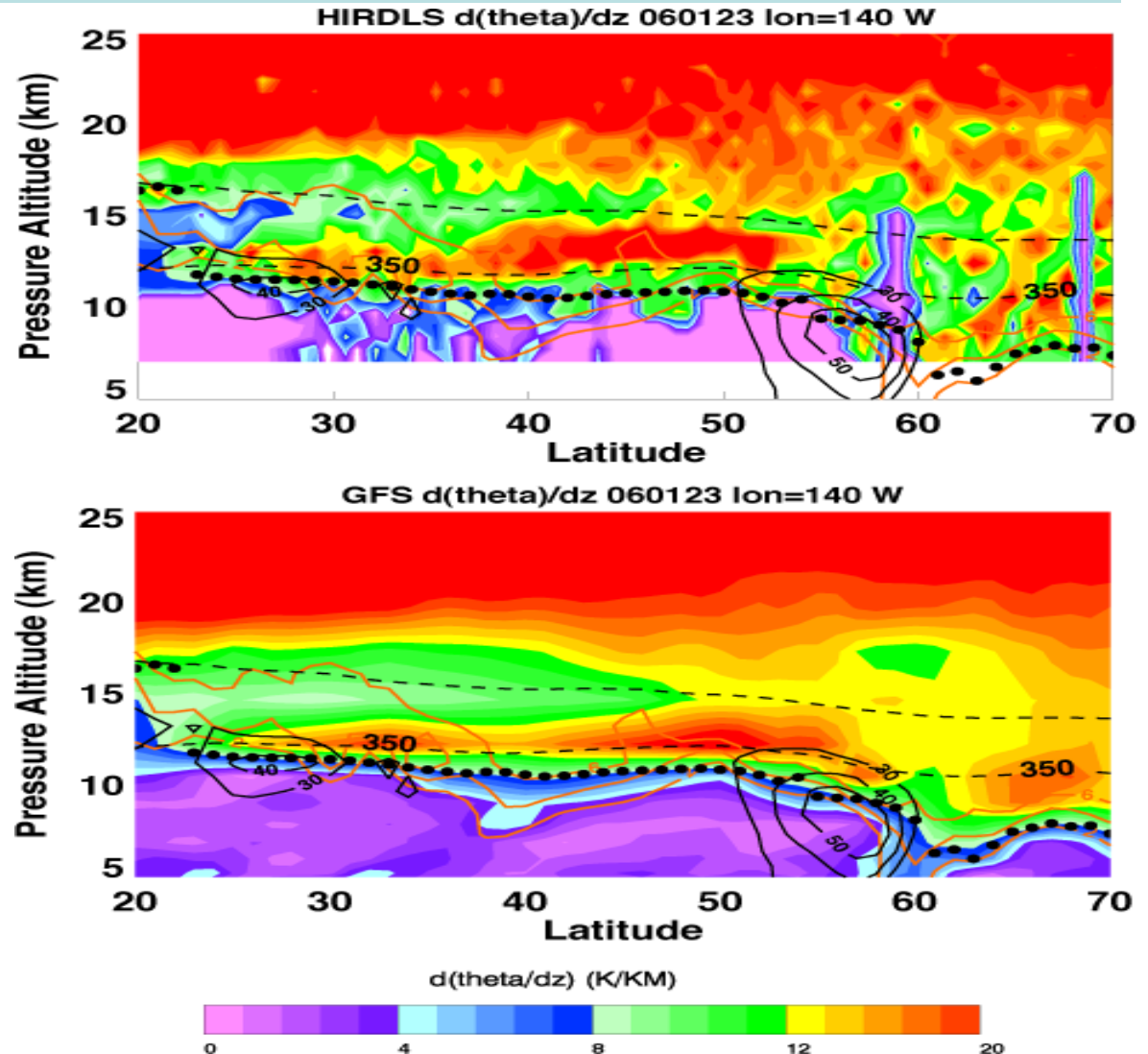
Double tropopause structure observed by MLS

/close MLS track and GEOS5 samples to the HIRDLS orbit/
and GEOS-5 T and O₃ distributions at 150 hPa

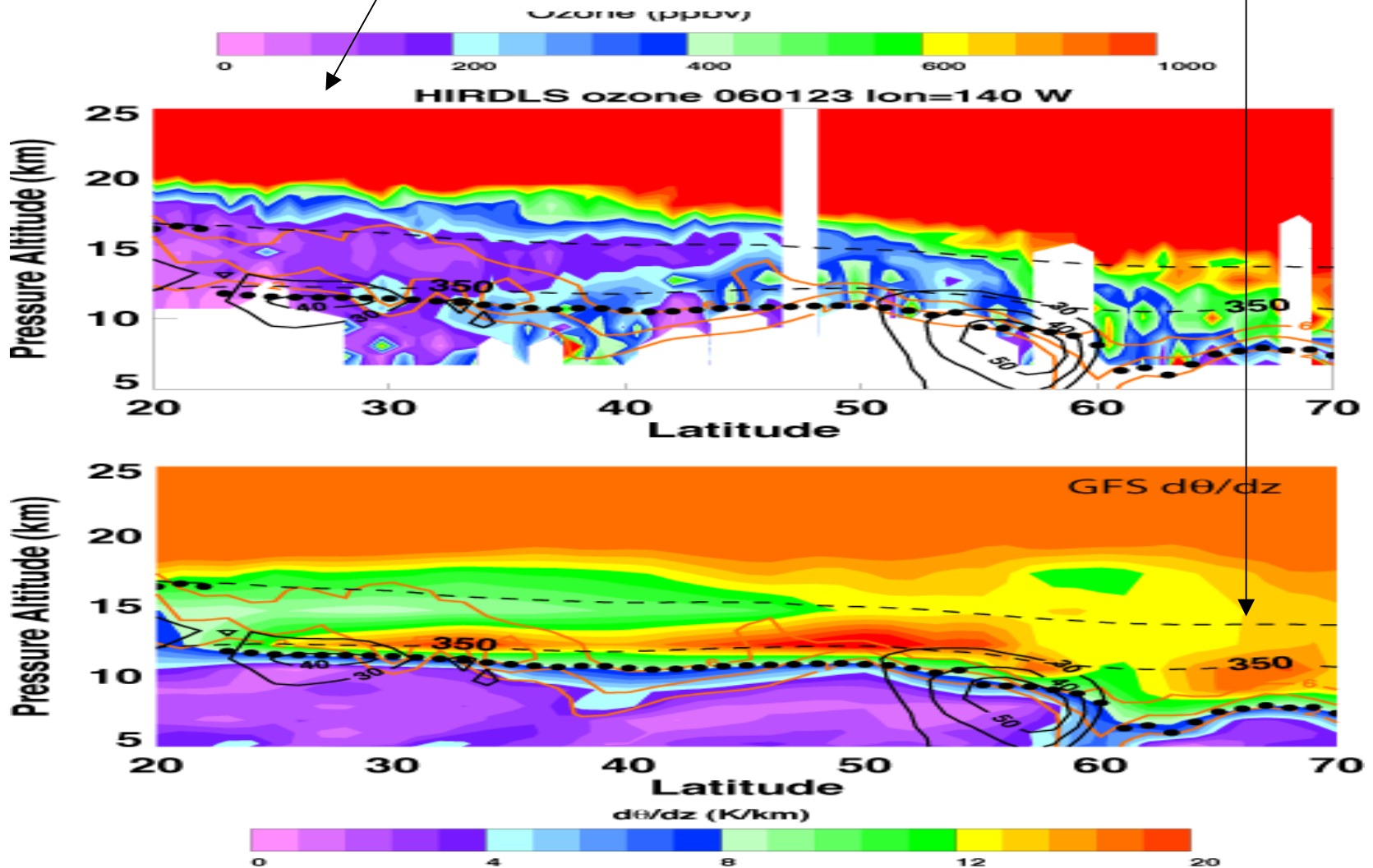


HIRDLS and GFS vertical gradients of PT, 23-01-2006

- HIRDLS- top plot
- GFS/NCEP- bottom plot
- Dashed line is 350 K and 400 K PT
- Dots mark positions of the thermal tropopause
- 2 and 4 PV unit marks positions of dynamical tropopause (brown line)
- Black contours present isolines of westward zonal jets along 140 W longitude.

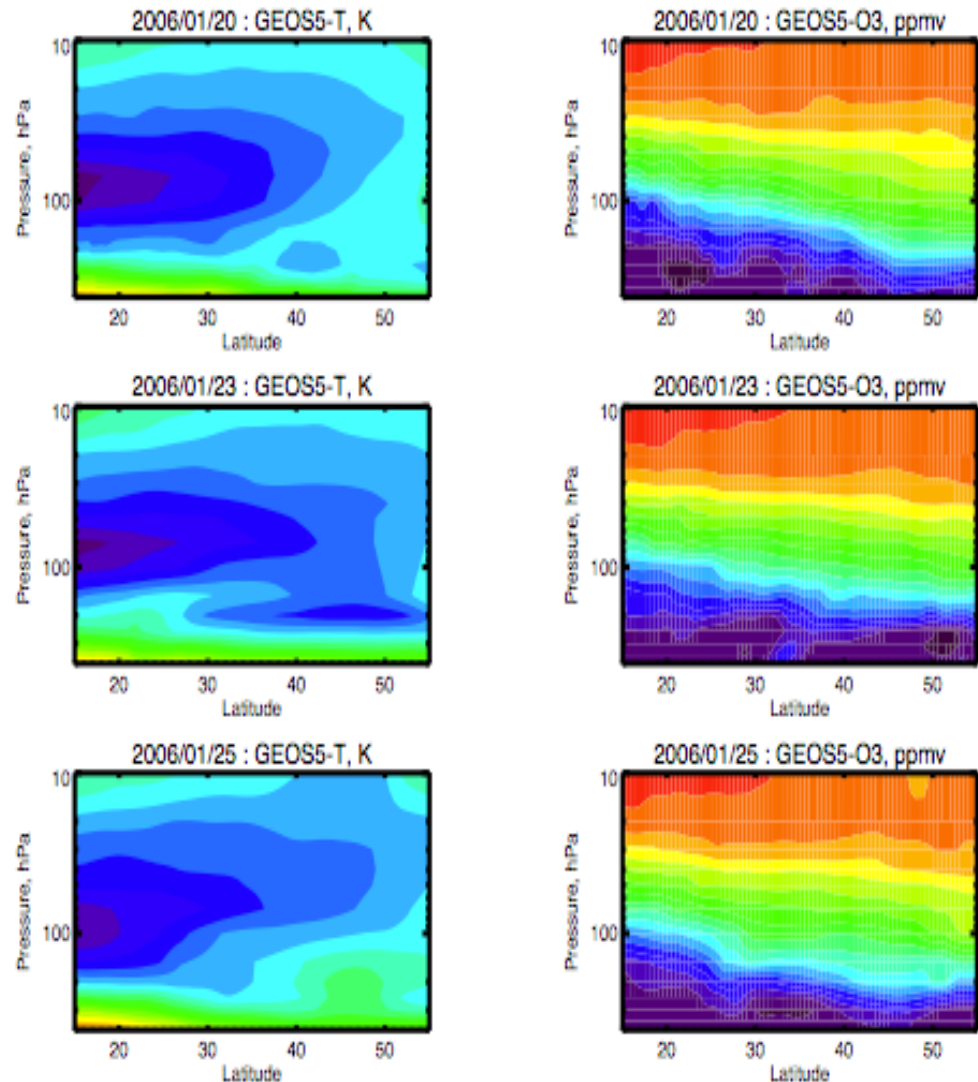


HIRDLS Ozone and GFS gradient of PT, 23-01-2006

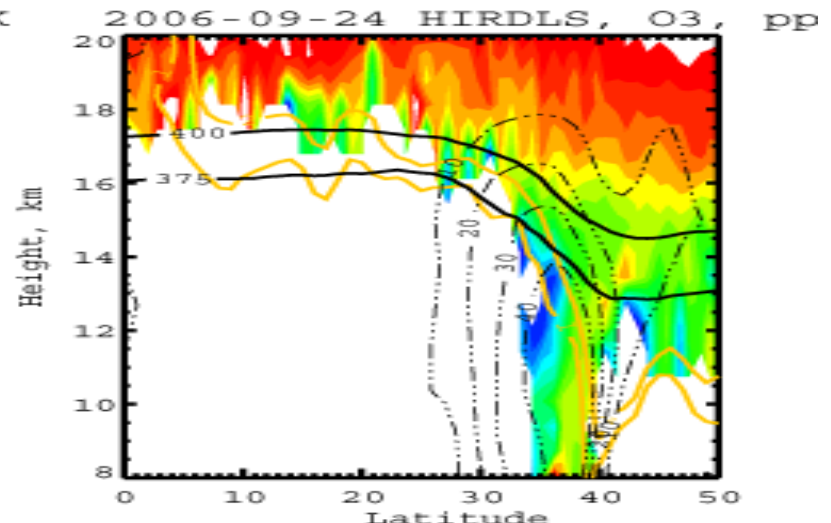
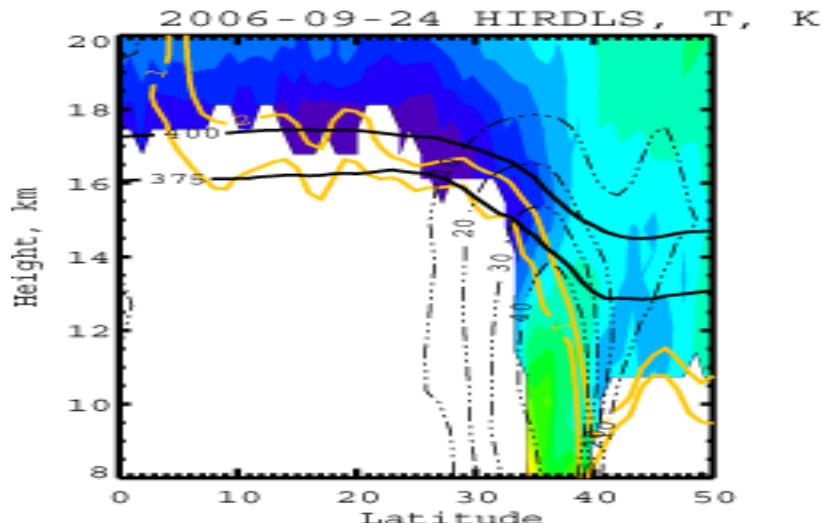
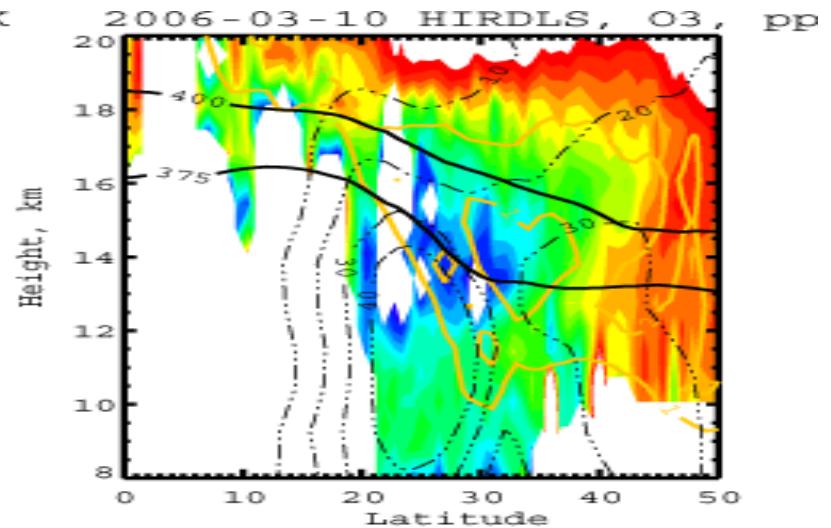
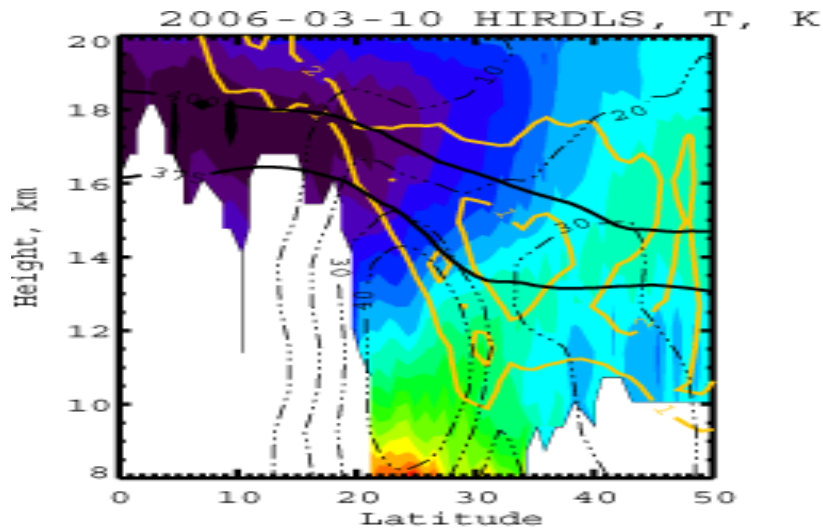


Evolution of Air Mass Intrusion and formation of double tropopause supported by GEOS-5

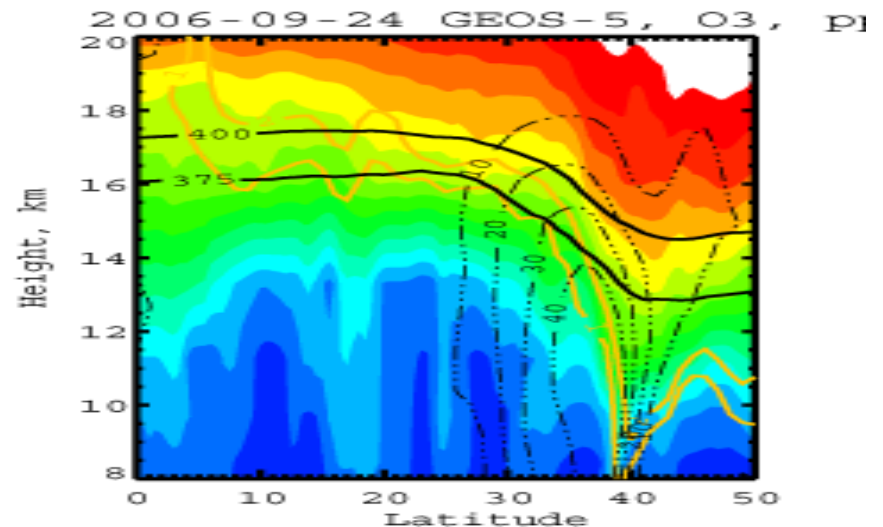
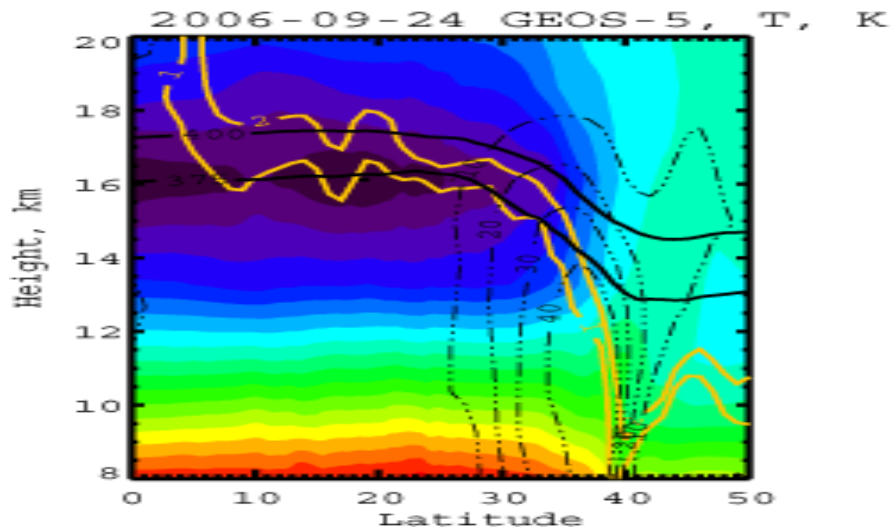
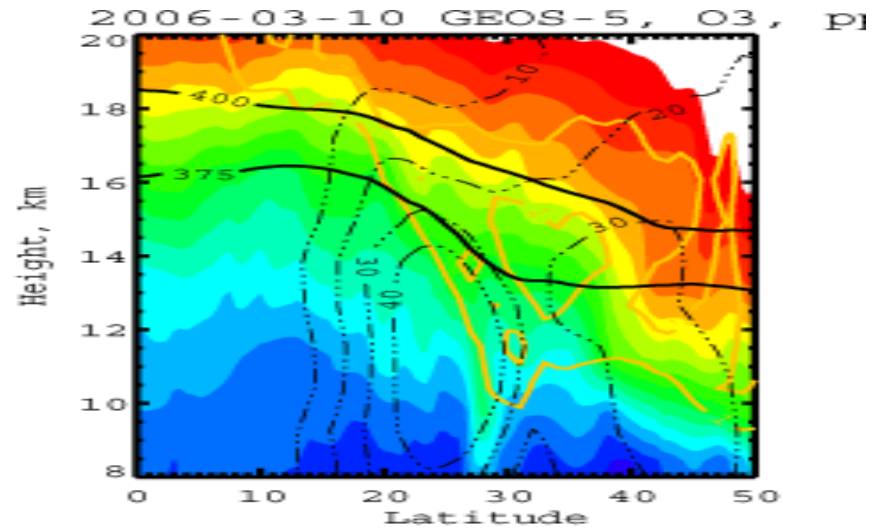
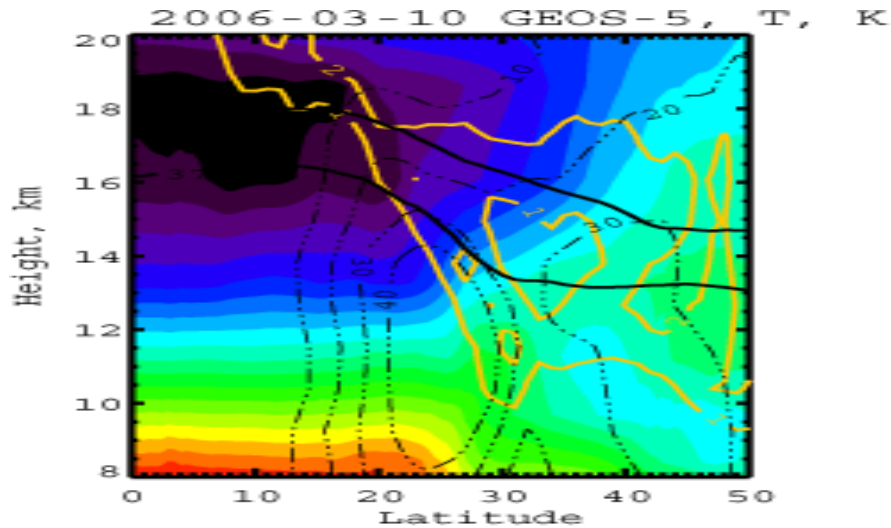
- T and Ozone vertical cross-sections produced by GEOS-5 analyses for a longitude in the same region as the HIRDLS observations.
- Days Illustrated, in panels from the top are January 20, 23 and 25.



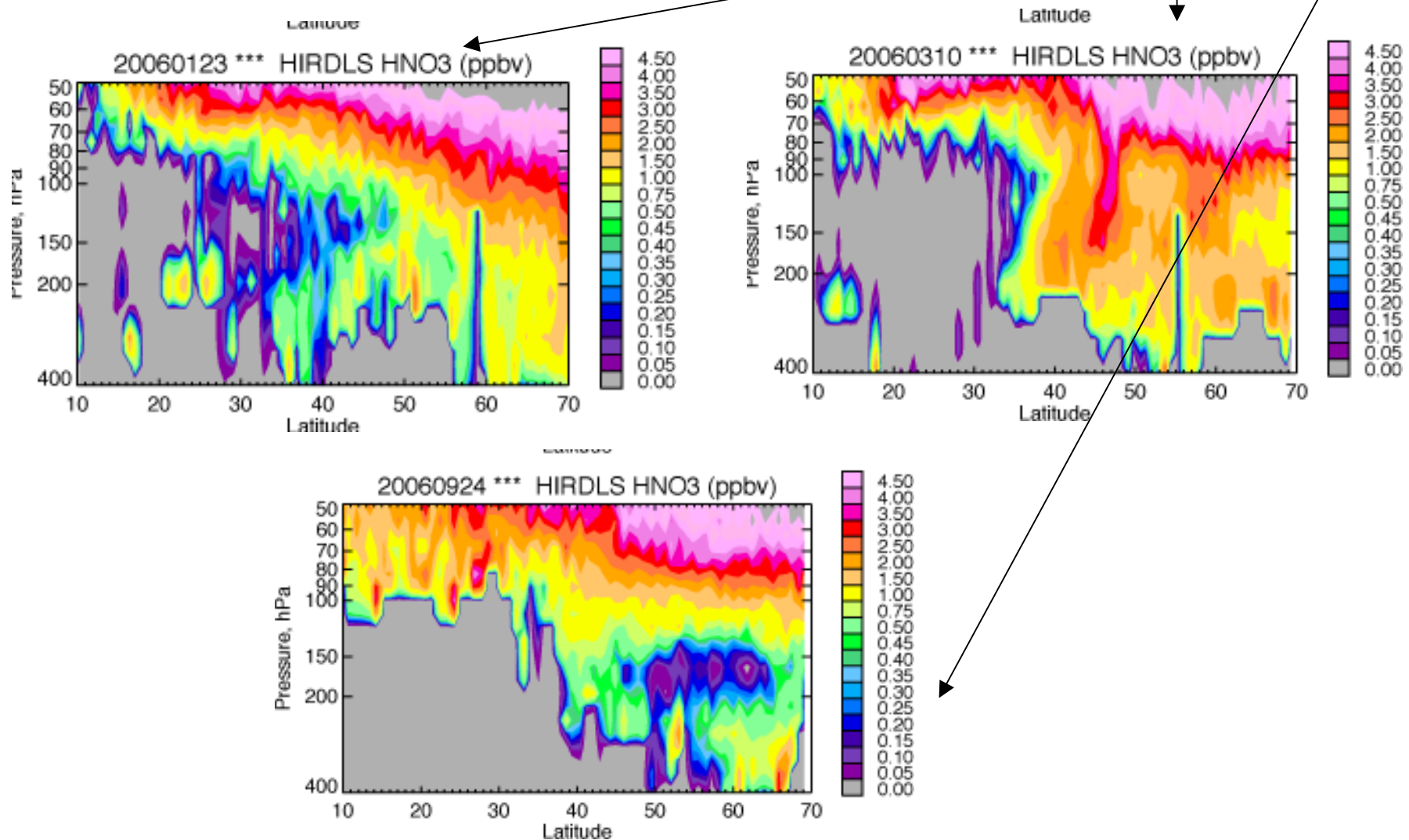
**Two stratospheric ozone intrusion events registered by HIRDLS in UT/LS: a) 2006-03-10, along ~15E orbit (top);
b) 2006-09-24, orbit ~ 97 W (bottom)**



**Two stratospheric ozone intrusion events produced by GEOS-5 at: a) 2006-03-10, along HIRDLS orbit ~15E (top);
b) 2006-09-24, orbit 97 W (bottom)**



HIRDLS 2006: Episodes of stratospheric intrusions of HNO_3 in the UT/LS for Jan, Mar, Sep



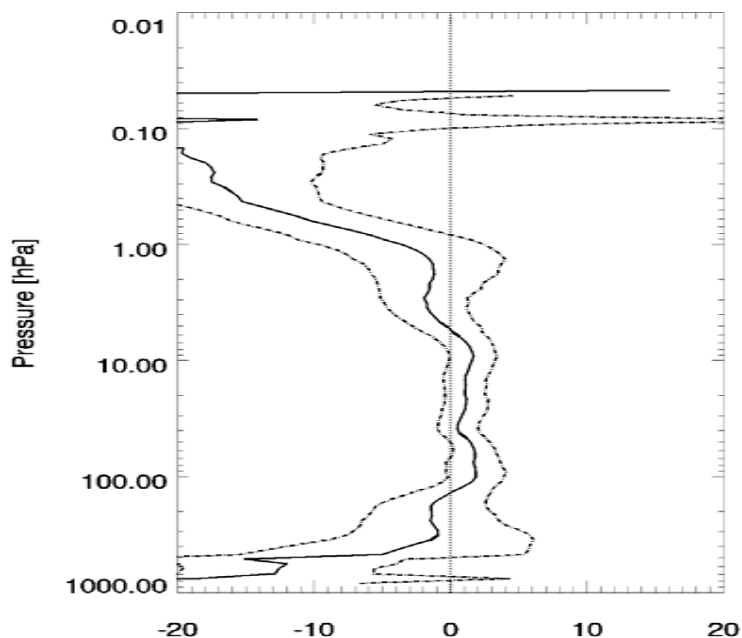
Concluding Remarks

- The along orbit cross-sections for this event indicate transport in a thin layer of low-ozone air from the low-latitude UT into the mid-latitude LS in a region between a double tropopause.
- The cross-sections also indicate transport of ozone in a deeper layer, from the mid-latitude LS into the low-latitude LS, below the poleward (northward) moving air.
- The large ozone increase at this location on January 25 (and possibly at other locations at other times) may be connected with the stratospheric warming that was taking place at this time.
- From this and other events, it appears that HIRDLS data can be used, with care, for studies of UT/LS phenomena.
- Future improvements in HIRDLS data should allow more detailed studies of the UT/LS, involving more species

Backup Slides

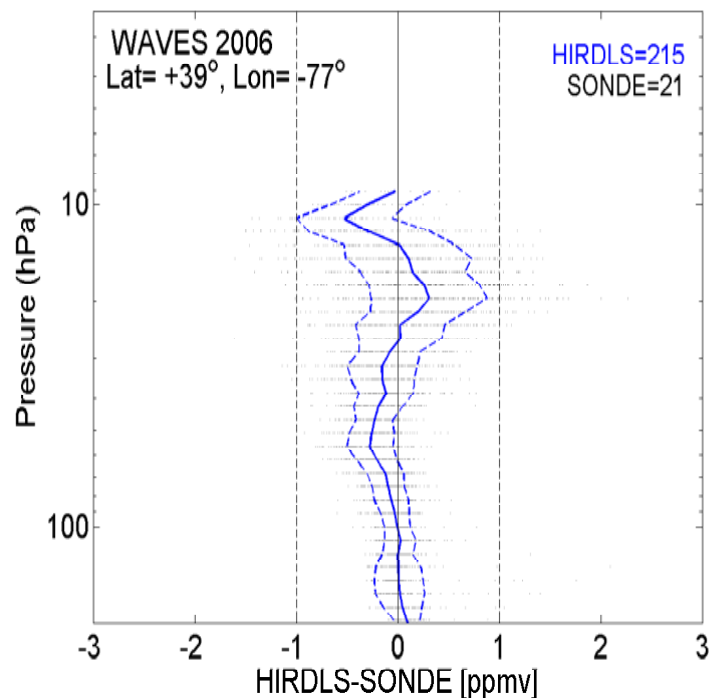
Summary of HIRDLS T and O₃ evaluation

ECMWF – HIRDLS, T, K



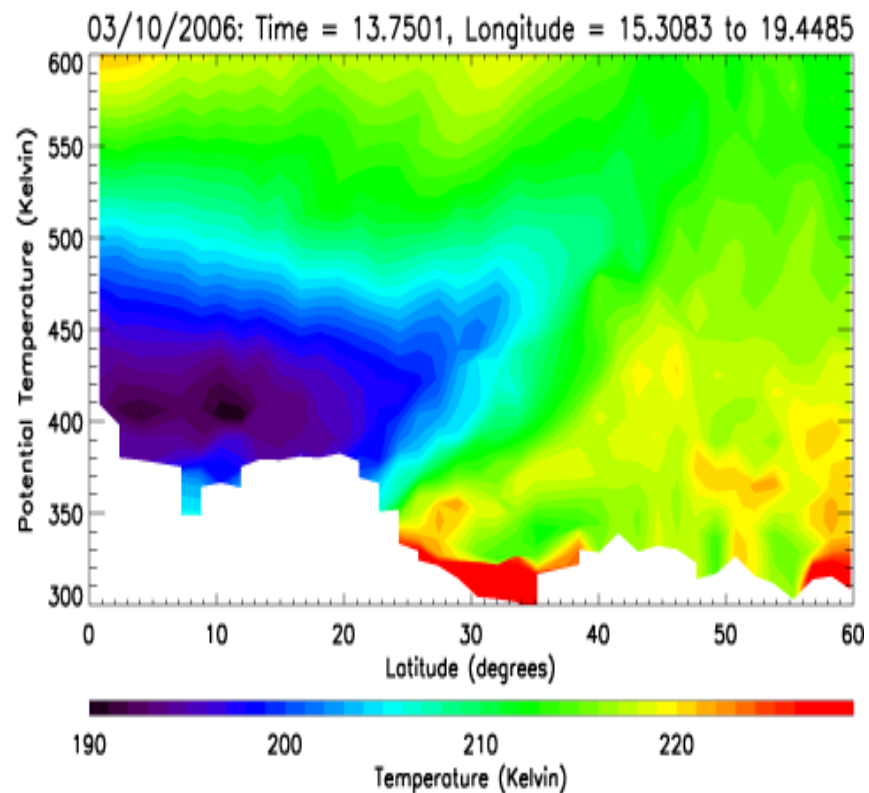
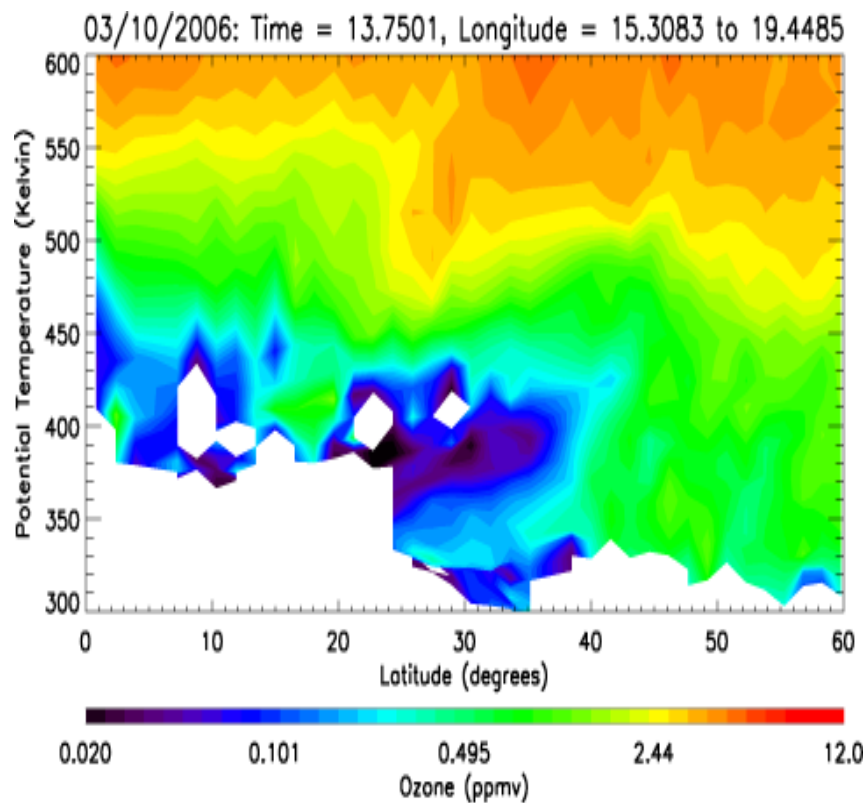
Comparison of HIRDLS temperatures with analyzed ECMWF temperatures interpolated to HIRDLS measurement locations. Mean and standard deviations of HIRDLS minus ECMWF temperature differences over full latitude range of HIRDLS measurements. From Gille et al., 2007.

Ozone Difference



Ozone difference between HIRDLS and ozonesondes (20+ sondes using 0.5% KI cathode solution) from the summer 2006 WAVES Campaign, sited in Beltsville, MD, 39°N, 77°W. Ozone differences are shown in terms of mixing ratio /Nardi et al., 2007/

March 10



HIRDLS: March 10/2006

